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PRINCIPAL INVESTIGATOR: Craig L. Wiegand

SPONSORING INSTITUTION: USDA, Agricultural Research Service
P. O. Box 267
Weslaco, TX 78596

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STATEMENT OF PROGRESS:

Cameron County

Basic statistics for studying atmospheric effects on Bendix 24-channel multispectral scanner (MSS) data recorded on computer compatible tape (CCT) for the saline soil study in Cameron County, described in Weslaco SKYLAB MPR #9 dated September, 1974, were determined. These data were collected at 5,700 ft and 16,000 ft on December 11, 1973. Exact aircraft coverage for the saline soil study area at both altitudes is described in Weslaco SKYLAB MPR #11 dated November, 1974. The overall mean, standard deviation, and the all possible correlation matrix were calculated at 5,700 ft and 16,000 ft for the complete study area for all 24 MSS channels. One percent of the total MSS data from 19 CCT at 5,700 ft and 6 CCT at 16,000 ft were randomly sampled to determine these statistics.

Table 1 presents the means and standard deviations for all 24 MSS channels at 5,700 ft and 16,000 ft. The mean MSS data in the visible spectral region, channels 1 to 5 (0.375 to 0.643 μm), were lower at 5,700 ft (53 to 75 digital value range) than at 16,000 ft (60 to 76 digital value range). The mean MSS data in the reflective and thermal infrared regions, channels 6 to 24 (0.65 to 13.0 μm), excluding channels 14 and 16, were higher at 5,700 ft (59 to 193 digital value range) than at 16,000 ft (48 to 171 digital value range). These results indicate that as altitude increases, atmospheric scattering and absorption tends to even out the mean MSS radiance difference of visible compared to reflective and thermal infrared spectral regions.

The standard deviations in the visible and reflective infrared spectral regions, channels 1 to 13, 23, and 24 (0.375 to 2.43 μm) were equal or higher at 5,700 ft (5 to 16 digital value range) than at 16,000 ft (5 to 13 digital value range). The standard deviation for the thermal infrared channels 17 to 22, excluding channel 20, (8.27 to 13.0 μm) at 5,700 ft (18 to 20 digital value range) is about the same as the standard deviation at 16,000 ft (18 to 21 digital value range). These results indicate that the data range of the visible and reflective infrared is decreased as altitude increases because of scattering and absorption in the atmosphere, but the data range in the thermal infrared channels remains about the same.

Table 2 presents the all possible correlation matrix of all 24 channels of Bendix MSS data at 5,700 ft (top half of matrix) and 16,000 ft (bottom half of matrix). The correlation matrix has been divided into 12 correlation blocks for convenience of interpretation. The visible channel MSS correlations (1 to 6) in the upper part of block 1 (5,700 ft) are in general higher than the correlations in the lower half (16,000 ft). Thus increasing altitude decreases the intercorrelations among the visible channels. Block 4 shows that increasing altitude does not change the reflective infrared MSS channel (7 to 11) correlations as much as the visible MSS channel correlations.

Correlations between the visible and reflective infrared channels (Table 2) are lower in general at 5,700 ft (correlation block 2) than at 16,000 ft (correlation block 3). Thus increasing altitude increases covariance among visible and reflective infrared channels. Whether the increased covariance with altitude is caused by increased interaction of information among adjacent MSS channels from the scene of interest or increased atmospheric variation common to all channels is not known.

Correlation blocks 5, 6, 7, and 8 (Table 2) indicate that increasing altitude does not change thermal channel (channels 17, 18, 19, 21, and 22) correlations as much as the visible channels. Indications are that covariance among visible and reflective infrared channels compared with thermal infrared channels is lower at 5,700 ft (correlation blocks 9 and 10) than at 16,000 ft (correlation blocks 11 and 12).

Investigations are continuing to identify the best Bendix MSS channels that relate to soil salinity ground measurements. Studies are also being conducted to determine whether MSS digital values from bare soil or vegetated surfaces relate best to soil salinity ground measurements.

Starr County

Ground truth data (vegetative composition and percent vegetative cover) have been tabulated for the seven range sites.

Microdensitometer readings have been completed on the following aerial films and filter combinations:

Films	Filter Bandwidths
EK 2424	0.7 to 0.8 µm
EK 2424	0.8 to 0.9 µm
Panatomic-X 22	0.5 to 0.6 µm
Panatomic-X 22	0.6 to 0.7 µm
Aerial color, SO-356	0.4 to 0.7 µm
Color infrared, SO-172	0.5 to 0.8 µm

Density readings relating to each of the seven range sites are being selected for statistical analyses. The objective is to relate density readings to salinity levels through the light reflective characteristics of the types of vegetation that are growing on the seven range sites.

TABLE 1 COMPARISON OF MEAN BENDIX 24-CHANNEL MSS DIGITAL DATA AT 5,700 FEET AND 16,000 FEET. DATA WERE COLLECTED ON DECEMBER 11, 1973 OVER PAREDES LINE ROAD AND FARM ROAD 510. ABOUT 1.0 PERCENT OF THE TOTAL DATA WAS RANDOMLY SELECTED TO DETERMINE THE MEAN AND STANDARD DEVIATION FOR THE COMPLETE STUDY AREA.

CHANNEL NUMBER	WAVELENGTH INTERVAL IN MICROMETERS	5,700 FEET		16,000 FEET	
		MEAN	SD	MEAN	SD
1	0.375- 0.405	53	5	61	5
2	0.40 - 0.44	56	7	74	6
3	0.466- 0.495	61	6	67	6
4	0.53 - 0.58	75	11	76	7
5	0.588- 0.643	59	8	60	5
6	0.65 - 0.69	71	11	65	8
7	0.72 - 0.76	76	12	62	10
8	0.77 - 0.81	91	16	70	13
9	0.82 - 0.88	85	15	61	12
10	0.981- 1.045	82	14	64	11
11	1.20 - 1.30	72	10	59	8
12	1.533- 1.62	53	9	50	8
13	2.30 - 2.43	53	95	55	8
14	3.78 - 4.04	252	11	251	12
15	4.50 - 4.76	99	20	72	17
16	6.0 - 7.0	83	16	3	14
17	8.27 - 8.70	168	19	146	21
18	8.80 - 9.30	186	20	167	21
19	9.38 - 9.876	193	18	171	19
20	10.1 -11.0	175	16	161	23
21	11.1 -12.0	165	18	147	19
22	12.0 -13.0	156	18	135	18
23	1.133- 1.17	59	6	48	6
24	1.06 - 1.095	75	15	67	13

TABLE 2 ALL POSSIBLE CHANNEL CORRELATIONS OF THE BENDIX 24-CHANNEL MSS, CHANNEL CORRELATIONS AT 5,700 FEET AND 16,000 FEET ARE THE UPPER AND LOWER PART OF CORRELATION MATRIX RESPECTIVELY, DATA WERE COLLECTED DECEMBER 11, 1973 OVER PAREDES LINE ROAD AND FARM ROAD 510. CORRELATIONS ARE CONVERTED TO TWO DIGIT INTEGER VALUES VARYING FROM -99 TO 99 (-0.99 TO .99).

CHANNEL NUMBERS	ALL POSSIBLE CORRELATIONS AT 5,700 FEET (TOP) AND 16,000 FEET (BOTTOM)																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1		89	87	74	77	75	20	12	9	18	22	49	46	-41	-9	-6	-16	-15	-5	17	-2	-14	33	25
2	89		95	83	87	85	22	10	4	12	17	49	56	-14	4	-23	-2	1	5	23	4	7	8	12
3	87	88		90	91	89	36	24	18	25	29	51	54	-10	6	-23	-1	2	6	21	5	-7	11	22
4	63	69	69		97	92	50	38	32	35	35	48	45	-8	1	-22	-11	-9	-5	12	-5	-14	14	32
5	64	69	74	95		98	45	32	27	33	37	57	59	-16	4	-16	-1	-1	6	17	7	-4	22	30
6	64	61	68	79	88		40	28	24	31	39	62	66	-19	5	-14	7	6	15	20	15	3	25	30
7	34	27	41	67	62	56		99	97	94	88	44	20	8	2	-18	-3	0	1	-39	-7	-9	29	79
8	33	24	38	61	55	55	99		99	96	88	39	12	6	-1	-14	-5	-3	-1	-44	-9	-9	32	81
9	34	23	39	57	53	57	97	99		98	92	42	15	0	-2	-9	-2	-1	2	-45	-5	-5	39	84
10	34	23	38	57	55	59	96	97	99		97	53	28	-9	-2	-8	2	3	8	-42	1	-2	47	88
11	37	27	45	56	58	64	91	92	95	97		63	43	-15	1	-3	12	12	19	-34	13	8	53	87
12	27	28	37	40	47	44	32	29	30	37	46		70	-30	-2	-4	19	19	30	-2	24	13	47	52
13	31	36	51	22	41	48	5	4	10	16	35	56		-19	18	-2	43	40	51	21	49	35	31	27
14	-6	24	10	-3	-8	-12	1	2	1	-3	0	-11	1		27	-51	29	36	13	-2	-2	2	-87	-3
15	-25	-12	-16	-12	-11	-21	-22	-24	-27	-24	-21	-2	9	6		9	46	46	43	23	39	37	-18	-9
16	5	-25	-11	3	7	11	-1	-2	-1	3	0	12	-1	-99	-6		19	1	17	17	36	40	47	8
17	-24	-10	1	-37	-23	-21	-35	-35	-31	-29	-15	10	45	26	31	-26		95	97	44	86	77	-14	-8
18	-19	0	4	-31	-22	-20	-28	-28	-25	-23	-11	6	36	49	27	-50	94		92	39	78	69	-21	-8
19	-27	-14	-6	-32	-19	-19	-36	-38	-35	-30	-17	18	43	9	39	-10	94	86		42	88	77	2	3
20	21	18	17	9	8	10	-3	-1	-1	-4	-9	-14	-8	0	-10	-1	-19	-17	-23		44	42	-13	-37
21	-21	-12	-3	-31	-16	-16	-41	-43	-39	-35	-22	15	48	-4	37	4	86	72	80	-17		81	14	0
22	-24	-16	4	-29	-17	-19	-35	-37	-34	-31	-19	12	42	-4	36	3	79	65	83	-17	90		7	-1
23	12	-16	5	23	28	30	34	32	33	38	37	31	13	-89	-9	88	-23	-44	-8	-11	2	2		66
24	16	5	23	51	45	33	80	77	75	76	72	36	6	-28	-12	28	-24	-28	-19	-17	-20	-17	58	

APPLICATION OF HIGH TEMPERATURE FILM THERMOCOUPLES IN THE STUDY OF THE TEMPERATURE FIELDS OF GAS TURBINE ENGINE ELEMENTS

L. S. Grigor'yev and D. F. Simbirskiy

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16. Abstract

Application of high temperature film thermocouples in the study of the temperature fields of gas turbine engine elements is studied.

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APPLICATION OF HIGH TEMPERATURE FILM THERMOCOUPLES IN THE STUDY OF THE TEMPERATURE FIELDS OF GAS TURBINE ENGINE ELEMENTS

L. S. Girgor'yev and D. F. Simbirskiy

The standard technique for studying the thermal-stressed state of elements operating at high temperatures is the analytic or experimental determination of the temperature fields with the subsequent calculation of the temperature stresses and deformations. /137*

Wire thermocouples, usually chromel-alumel, are used for studying the temperature fields of such gas turbine engines (GTE) elements as the combustion chambers, disks, nozzle and rotor blades of the turbine. In a majority of cases, the thermocouple preparation of parts, particularly those with gas or air flowing around them, leads to a distortion of their temperature field and the flow conditions. This distortion can be reduced by the application of semi-synthetic thermocouples, for which one of the thermoelectrodes is the metal of the investigated part B (Figure 1,a). Thus, the number of wire thermoelectrodes A is reduced by a factor of 2, which is particularly important for the thermometry of rotating parts with the use of slip rings, which limits the number of measuring points. Such a scheme

*Numbers in the margin indicate pagination in the original foreign text.

is also suitable for film thermocouples, which have been proposed for studying the temperature fields of turbine blades and profile models under thermocyclic loads [3].

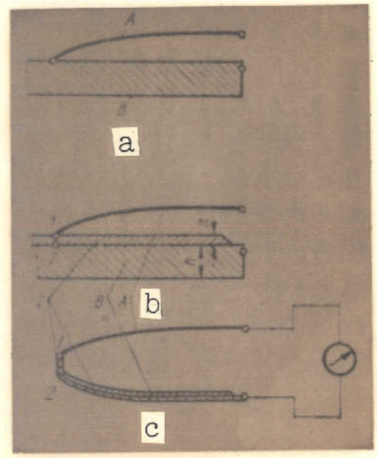

Figure 1.

The application of semi-synthetic thermocouples leads to certain peculiarities in the measuring and calibration technique. Such thermocouples are structurally in the form of wire (film) thermoelectrodes A, welded by a contact weld to the metal of the investigated part B at the point of the temperature measurement, and laid along the part in the most convenient manner. The second thermoelectrode for all the thermocouples is the material of the part. The signal of each thermocouple must be recorded with open circuits of the remaining ones, i.e., it is necessary to use multi-point automatic potentiometers or other circuits with switching units. Usually, either the second thermoelectrode is connected with the recording instrument by a lead with the same thermoelectric properties, or a circuit is used with the introduction of a compensated conductor pair, whose characteristics coincide with the characteristics of the semi-synthetic thermocouple [3].

The main disadvantage of semi-synthetic thermocouples is the possible errors related to the use of structural materials as the thermoelectrodes. The thermoelectric properties of several heat-resistant structural materials have been investigated. The thermoelectric instability and inhomogeneity of the thermoelectric properties along the length have been investigated.

The thermal emf of thermocouples, in particular, of base metals and their alloys, can change notably during operation; the accuracy and reliability of measurements are then reduced. Thermoelectric instability of materials arises due to changes in the chemical composition (because of corrosion and contaminants), and also in the microstructure of the material. Changes in chemical composition, most significant at the surface, lead to the appearance of a surface layer C (Figure 1,b) with thermoelectric properties differing from the properties of the basic material B. Because of this, the thermocouple circuit changes, since the so-called galvanic thermocouple B — C (Figure 1,c) arises in the circuit of the third thermoelectrode C (Figure 1,b). Since the thickness of the surface layer is small and the temperatures at points 1 and 2 do not differ in practice, the error introduced by the third thermoelectrode can be neglected. /138

The effect of the galvanic thermocouple, whose thermal emf depends on the ratio of the electrical resistances of the surface layer and the basic metal (i.e., on the ratio of their thicknesses a and h), can be significant [2]. For massive thermoelectrodes, the ratio a/h is small, and the instability of the thermocouple can be neglected. Thus, in studying the thermoelectrical instability of structural materials, the main attention was given to the study of the structural changes in the material arising under the effect of high temperatures.

The technique [1], standard for wire thermoelectrodes, which involves taking the characteristics of the thermal emf after annealing at various temperatures, where the sample is subjected to annealing over its entire length, was selected for investigating thermoelectric instability. The values of the thermal emf were determined relative to the platinum branch of a standard platinum vs. platinum-rhodium thermocouple of second class.

The test samples of dimensions 500 × 5 × 3 mm, which were subjected to the required annealing, and the platinum vs. platinum-rhodium thermocouple were welded into a bundle. The measurements of thermal emf were performed with heating and cooling of the samples together with an oven at temperatures from 20 to 1000° C.

The changes in thermal emf were investigated for the heat-resistant structural materials enumerated in Figure 2. The samples of these materials were subjected to isochronous annealing for 2 hours in air at temperatures of 800, 1000, and 1200° C, and in the products of kerosene combustion at a temperature of 1200° C. The duration of the annealing was selected on the basis of roughly the time necessary for performing the thermometry.

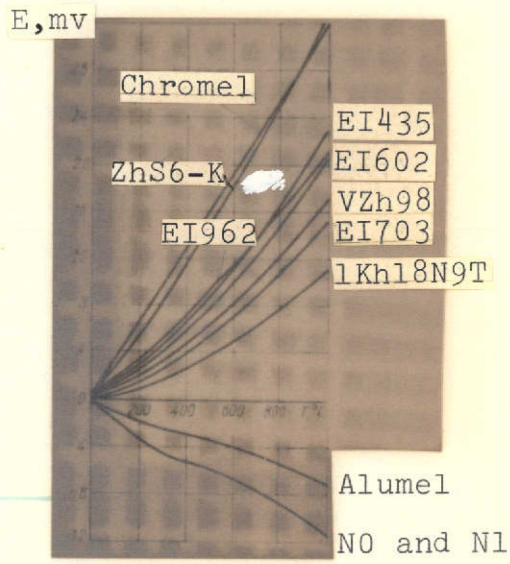

Figure 2.

The results of the measurements of thermal emf, relative to the platinum branch of the standard platinum vs. platinum-rhodium thermocouple, are presented in Figure 2. As a characteristic of the change of thermal emf of the samples as a result of annealings, the relative sampling dispersion δ was examined, which characterizes the degree of scatter of the experimental data, and is defined as: /139

$$\delta = \frac{1}{\sqrt{n}} \cdot \frac{1}{k} \sum_{j=1}^{k} \sqrt{\sum_{i=1}^{n} \left[\frac{E_i(t_j, 0) - \bar{E}_i(t_j, 0)}{\bar{E}_i(t_j, 0)} \right]^2},$$

where $E_i(t_j, 0)$ is the value of the thermal emf for a sample subjected to one of the annealings; $\bar{E}_i(t_j, 0)$ is the arithmetic-mean value of the thermal emf for the series of samples of one material subjected to various annealings; t_j is the temperature in the range 0 - 1000° C; k is the number of points for which the dispersion is determined (k = 10); n is the number of annealings (n = 4).

In the range 0 - 1000° C, the average value of δ, characterizing the stability of the thermoelectric properties of the investigated materials, was approximately 0.5% (for VZh98, δ = 1.17%). It is obvious that, except for VZh98, the investigated structural materials were not inferior to, and sometimes exceeded, alumel in the stability of the thermal emf characteristics after high-temperature annealing.

To determine the causes of the thermal emf instability and the effect of microstructure change on the thermoelectric properties, microsections were investigated of the original and previously annealed structural materials EI602, EI703, EI435, VZh98, EI962, 1Kh18N9T, ZhS6-K, and also Mark N1 nickel wire and Mark NO nickel sheet. The investigation was carried out on sections etched with aqua regia under the MIM-8M microscope.

The investigation showed that the increase of annealing temperature leads to a recrystallization of the metals. The collective recrystallization for nickel occurs at a temperature of 800° C, and at 1000° C for the remaining alloys. The alloy VZh98 is an exception. The microstructure of the alloys EI435, EI602, EI703, 1Kh18N9T, ZhS6-K is a homogeneous $\gamma\gamma$-solid solution; the microstructure of the alloy VZh98 is the same, but with a large number of inclusions, located both within the grains and along the grain boundaries. Evidently, the presence of the second phase and its preferential location along grain boundaries in the alloy VZh98 worsens the stability of the thermal emf. The growth of the grains, which is observed in a majority of the alloys, has an insignificant effect on their thermoelectric properties. The thermoelectric inhomogeneity of samples of the structural materials of length 150 mm was found to be approximately the same, and did not exceed 30 mkV.

Thus, some of the heat-resistant structural materials used in GTE are suitable as the second thermoelectrode of semi-synthetic thermocouples for short term measurements in air and in the products of kerosene combustion at temperatures up to 1200° C.

REFERENCES

1. Issledovaniye splavov dlya termopar (Thermocouple Alloy Research), Issue 22, Moscow, "Metallurgiya" Press, 1964.

2. Issledovaniye splavov dlya termopar (Thermocouple Alloy Research), Issue 25, Moscow, "Metallurgiya" Press, 1967.

3. Simbirskiy, D. F. et al. Teploenergetika, Vol. 8, 1970.

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